

**REMARKS/ARGUMENTS**

This is responsive to the Official Action of February 22, 2007. Claims 1-7 are pending in the application.

The examiner's attention is directed to the Information Disclosure Statement filed August 2, 2007 which also identifies two commonly assigned, co-pending applications that may be related to the subject matter of the claims of the present application.

Claim 2 has been amended and written in independent form.

The issues raised in the outstanding Official Action relate to various prior art-based rejections all founded upon newly cited U.S. patent 6,746,768 to Greinke et al. The Official Action contains three separate prior art-based rejections, the first in item 2, based upon alleged anticipation and the other two (item 5 on page 3 and item 5 on page 4) of alleged "obviousness". All of these rejections are based upon a misunderstanding/misapplication of this newly cited document. Apparently located in a word search, Greinke et al discloses "phosphoric acid" at column 6, line 4 from a group of "mineral" or inorganic acids including nitric acid, chromic acid and sulfuric acid. In the Official Action the term "phosphoric acid" or "a phosphoric acid" is misconstrued. Phosphoric acid is a well known and well recognized material and is also known as orthophosphoric acid. Attached is a copy of the relevant information from Wikipedia (August 16, 2007) clearly showing that phosphoric acid (or orthophosphoric acid as it is sometimes known) is **not** an organic acid – there are no carbon atoms in its structure. It is based upon this fundamental misunderstanding of the term "phosphoric acid" that the balance of the Official Action is based.

Greinke discloses a system for managing the heat from a heat source such as an electronic component, and describes a mixture including phosphoric acid as an intercalating agent, which is used when acid-treated graphite is manufactured as acknowledged in applicants' specification. Phosphoric acid disclosed in Greinke together with sulfuric acid and nitric acid is also called orthophosphoric acid – it is an inorganic acid, and is different from an organic phosphorus compounds in the present application. The flexible graphite sheet disclosed in Greinke corresponds to a conventional expanded graphite sheet as seen from paragraph [0002] of applicants' specification. The sheet including orthophosphoric acid mixed with acid-treated

graphite does not provide the advantageous effects as shown in comparative examples 1-6 of the present application – *see* pages 21-23, tables 9-10 and a discussion of the results on pages 28-29.

As explained above, Greinke discloses a system for managing the heat from a heat source in which a flexible graphite sheet is used because of its low thermal resistance and this ability to conform to the surfaces of the heat source. Additionally the oil<sup>1</sup> makes the graphite sheet “softer” and more amenable to surface deformations and irregularities of the heat source. (*See* column 9, lines 50-59 of Greinke.) The primary requirements with respect to the oil used in Greinke include having higher thermal conductivity than the air present in the pores of the graphite sheets. (*See* column 10, lines 27-34 of Greinke.)

To sum up, in Greinke, a flexible graphite sheet which contains oil, liquid at room temperature, is used because of its ability to conform to the surfaces of the heat source. Therefore, Greinke does not mention resistance to oxidative wear at high temperatures which is the subject of the present invention.

A secondary reference published Japanese application 10-101316 is cited and combined with the Greinke U.S. patent discussed above; *see* item 5 (the second one) on page 4 of the Official Action. The Abstract refers to “a phosphorus compound” making no distinction as to whether it is organic, inorganic or whatever, certainly an acid is not specified.

The JP citation describes a flame retardant sheet which comprises expanded graphite particles, phosphorus compounds and unexpanded inserted graphite particles which expand with heat by a fire to acquire an adiabatic efficiency in case of a fire. Citation ‘316A states that “in order to give sufficient adiabatic efficiency, when the ratio of the insertion graphite particle which is not expanding is made high, there is a problem of the reinforcement of complex falling and it becoming impossible to maintain a configuration. Even if artificers made the ratio of an insertion graphite particle high by adding phosphorus compounds to the graphite composite which consists of a flexible graphite particle which expanded, and a non-expanded insertion

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<sup>1</sup> An oil is an essential component – *see* the last sentence of the Abstract and claims 1(2), 2, 3, 8-10, 12(b), 13-15, 17(a), 19(B), 20 and 21.

graphite particle, they found out that the reinforcement which can maintain a configuration was obtained and resulted in invention". (See paragraphs [0003] and [0004] of citation '316A.) Therefore, citation '316A discloses "a phosphorus compound" which serves as a binding material of graphite particle, but does not teach phosphorus compounds which improve resistance to heat and oxidation of the expanded graphite sheet.

In conclusion, Greinke does not mention resistance to oxidative wear at high temperature as in the present application. The phosphoric acid which Greinke teaches is one of the inorganic acids which are used when graphite particles are treated with acids in the present application. Citation '316A teaches phosphorus compounds merely as binding materials.

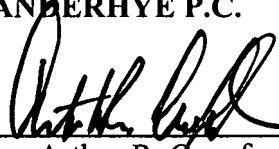
Therefore, it is illogical to use phosphorus compounds of citation '316A in a mixture including phosphoric acid of Greinke.

For the above reasons it is respectfully submitted that the claims of this application define inventive subject matter and that they are neither anticipated by nor rendered obvious from the disclosure of either or both of the cited documents. Reconsideration is requested. Should the examiner require further information, please contact the undersigned.

Respectfully submitted,

NIXON & VANDERHYE P.C.

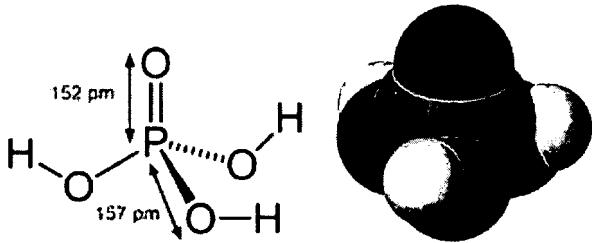
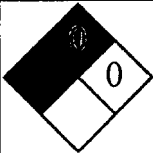
By: \_\_\_\_\_

  
Arthur R. Crawford  
Reg. No. 25,327

ARC:eaw  
901 North Glebe Road, 11th Floor  
Arlington, VA 22203-1808  
Telephone: (703) 816-4000  
Facsimile: (703) 816-4100

# Phosphoric acid

From Wikipedia, the free encyclopedia

Phosphoric acid	
	
General	
Other names	Orthophosphoric acid
Molecular formula	H <sub>3</sub> PO <sub>4</sub>
SMILES	OP(O)(O)=O
Molar mass	98.0 g/mol
Appearance	white solid or colourless, viscous liquid (>42°C)
CAS number	7664-38-2 ( <a href="http://www.nlm.nih.gov/cgi/mesh/2006/MB_cgi?term=7664-38-2&amp;rn=1">http://www.nlm.nih.gov/cgi/mesh/2006/MB_cgi?term=7664-38-2&amp;rn=1</a> )
Properties	
Density and phase	1.685 g/ml, liquid
Solubility in water	miscible
Melting point	42.35 °C, 107.6°F, 567.27°R
Boiling point	158 °C, 415.4°F, 875.1°R <i>decomp.</i>
Acidity (pK <sub>a</sub> )	2.12, 7.21, 12.67
Viscosity	85% aqueous solution ? cP at ? °C
Hazards	
MSDS	External MSDS
EU classification	Corrosive (C)
NFPA 704	
R-phrases	R34
S-phrases	(S1/2), S26, S45
Supplementary data page	
Structure and properties	<i>n</i> , ε <sub>r</sub> , etc.
Thermodynamic data	Phase behaviour Solid, liquid, gas
Spectral data	UV, IR, NMR, MS
Related compounds	
	Nitric acid

Other anions	Arsenic acid
Other cations	Ammonium phosphate Trisodium phosphate
Related Phosphorus acids	Hypophosphorous acid Phosphorous acid Pyrophosphoric acid Tripolyphosphoric acid Hypophosphoric acid Perphosphoric acid Permonophosphoric acid
Except where noted otherwise, data are given for materials in their standard state (at 25 °C, 100 kPa) Infobox disclaimer and references	

**Phosphoric acid**, also known as **orthophosphoric acid** or **phosphoric(V) acid**, is a mineral (inorganic) acid having the chemical formula  $\text{H}_3\text{PO}_4$ . Alternatively, orthophosphoric acid molecules can combine with themselves to form a variety of compounds referred to as **phosphoric acids** in a more general way. The term "phosphoric acid" can also refer to a chemical or reagent consisting of phosphoric acids, usually mostly orthophosphoric acid.

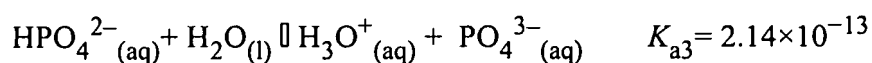
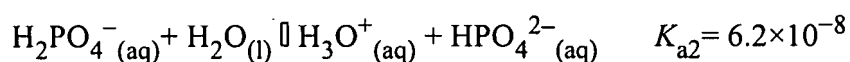
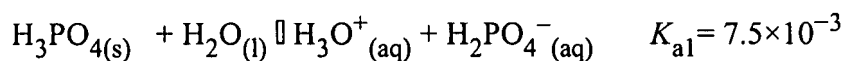
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## Orthophosphoric acid chemistry

Pure anhydrous phosphoric acid is a white solid that melts at 42.35 °C to form a colorless, viscous liquid.

Most people and even chemists simply refer to orthophosphoric acid as "phosphoric acid", which is the IUPAC name for this compound. The prefix *ortho*- usually is used when one wants to distinguish it from other phosphoric acids called polyphosphoric acids. Orthophosphoric acid is a non-toxic, inorganic, rather weak triprotic acid which, when pure, is a solid at room temperature and pressure. The chemical structure of orthophosphoric acid is shown above in the data table. Orthophosphoric acid is a very polar molecule, therefore it is highly soluble in water. The oxidation state of phosphorus (P) in ortho- and other phosphoric acids is +5; the oxidation state of all the oxygens (O) is -2 and all the hydrogens (H) is +1. Triprotic means that an orthophosphoric acid molecule can dissociate up to three times, giving up an  $\text{H}^+$  each time, which typically combines with a water molecule,  $\text{H}_2\text{O}$ , as shown in these reactions:



The anion after the first dissociation,  $\text{H}_2\text{PO}_4^-$ , is the *dihydrogen phosphate* anion. The anion after the second dissociation,  $\text{HPO}_4^{2-}$ , is the *hydrogen phosphate* anion. The anion after the third dissociation,  $\text{PO}_4^{3-}$ , is the **phosphate** or **orthophosphate** anion. For each of the dissociation reactions shown above, there is a separate acid dissociation constant, called  $K_{\text{a}1}$ ,  $K_{\text{a}2}$ , and  $K_{\text{a}3}$  given at 25°C. Associated with these three dissociation constants are corresponding  $\text{p}K_{\text{a}1}=2.12$ ,  $\text{p}K_{\text{a}2}=7.21$ , and  $\text{p}K_{\text{a}3}=12.67$  values at 25°C. Even though all three hydrogen (H) atoms are equivalent on an orthophosphoric acid molecule, the successive  $K_{\text{a}}$  values differ since it is energetically less favorable to lose another  $\text{H}^+$  if one (or more) has already been lost and the molecule/ion is more negatively charged.

Because the triprotic dissociation of orthophosphoric acid, the fact that its conjugate bases (the phosphates mentioned above) cover a wide pH range, and because phosphoric acid/phosphate solutions are generally non-toxic, mixtures of these types of phosphates are often used as buffering agents or to make buffer solutions, where the desired pH depends on the proportions of the phosphates in the mixtures. Similarly, the non-toxic, anion salts of triprotic organic citric acid are also often used to make buffers. Phosphates are found pervasively in biology, especially in the compounds derived from phosphorylated sugars, such as DNA and RNA and adenosine triphosphate (ATP). There is a separate article on phosphate as an anion or its salts.

Upon heating orthophosphoric acid, condensation of the phosphoric units can be induced by driving off the water formed from condensation. When one molecule of water has been removed for each two molecules of phosphoric acid, the result is pyrophosphoric acid ( $\text{H}_4\text{P}_2\text{O}_7$ ). When an average of one molecule of water per phosphoric unit has been driven off, the resulting substance is a glassy solid having an empirical formula of  $\text{HPO}_3$  and is called **metaphosphoric acid**.<sup>[1]</sup> Metaphosphoric acid is a singly anhydrous version of orthophosphoric acid and is sometimes used as a water- or moisture-absorbing reagent. Further dehydrating is very difficult and can only be accomplished by means of an extremely strong desiccant (and not by heating alone). It produces *phosphoric anhydride* which has an empirical formula  $\text{P}_2\text{O}_5$ , although an actual molecule has a chemical formula of  $\text{P}_4\text{O}_{10}$ . Phosphoric anhydride is a solid which is very strongly moisture-absorbing and is used as a desiccant.

## Phosphoric acid as a chemical reagent

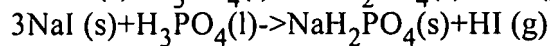
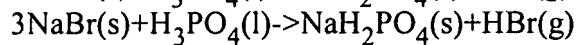
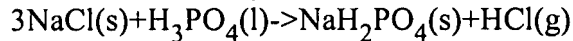
Pure 75-85% aqueous solutions (the most common) are clear, colourless, odourless, non-volatile, rather viscous, syrupy liquids, but still pourable. Phosphoric acid is very commonly used as an aqueous solution of 85% phosphoric acid or  $\text{H}_3\text{PO}_4$ . Because it is a concentrated acid, an 85% solution can be corrosive, although not toxic when diluted. Because of the high percentage of phosphoric acid in this reagent, at least some of the orthophosphoric acid is condensed into polyphosphoric acids in a temperature-dependent equilibrium, but for the sake of labeling and simplicity, the 85% represents  $\text{H}_3\text{PO}_4$  as if it were all orthophosphoric acid. Other percentages are possible too, even above 100%, where the phosphoric acids and water would be in an unspecified equilibrium, but the overall elemental mole content would be considered specified. When aqueous solutions of phosphoric acid and/or

phosphate are dilute, they are in or will reach an equilibrium after a while where practically all the phosphoric/phosphate units are in the ortho- form.

## Preparation of hydrogen halides

Phosphoric acid reacts with halides to form the corresponding hydrogen halide gas (steamy fumes are observed on warming the reaction mixture).

This is a common practice for the laboratory preparation of hydrogen halides.



## Rust removal

Phosphoric acid may be used by direct application to rusted iron, steel tools or surfaces to convert iron (III) oxide (rust) to a water soluble phosphate compound. It is usually available as a greenish liquid, suitable for dipping (acid bath), but is more generally used as a component in a gel, commonly called **naval jelly**. As a thick gel, it may be applied to sloping, vertical, or even overhead surfaces. Care must be taken to avoid acid burns of the skin and especially the eyes, but the residue is easily diluted with water. When sufficiently diluted it can even be nutritious to plant life, containing the essential nutrients phosphorus and iron. It is sometimes sold under other names, such as "rust remover" or "rust killer". It should not be directly introduced into surface water such as creeks or into drains, however. After treatment, the reddish-brown iron oxide will be converted to a black iron phosphate compound coating that may be scrubbed off. Multiple applications of phosphoric acid may be required to remove all rust. The resultant black compound can provide further corrosion resistance (such protection is somewhat provided by the superficially similar Parkerizing and blued electrochemical conversion coating processes.) After application and removal of rust using phosphoric acid compounds, the metal should be oiled (if to be used bare, as in a tool) or appropriately painted, most durably by using a multiple coat process of primer, intermediate, and finish coats.

## Processed food use

Food grade phosphoric acid is used to acidify foods and beverages such as various colas, but not without controversy as to its health effects. It provides a tangy taste, and being a mass-produced chemical, is available cheaply and in large quantities. The low cost and bulk availability is unlike more expensive natural seasonings that give comparable flavors, such as ginger for tangyness, or citric acid for sourness, obtainable from lemons and limes. (However most citric acid in the food industry is not extracted from citrus fruit, but fermented by *Aspergillus niger* mold from scrap molasses, waste starch hydrolysates and phosphoric acid.) It is labeled as E number **E338**.

## Biological effects on bone calcium

Phosphoric acid, used in many soft drinks (primarily cola), has been linked to lower bone density in epidemiological studies. For example a study<sup>[2]</sup> using dual-energy X-ray absorptiometry rather than a questionnaire about breakage, provides reasonable evidence to support the theory that drinking cola results in lower bone density. This study was published in the American Journal of Clinical Nutrition. A total of 1672 women and 1148 men were studied between 1996 and 2001. Dietary information was

collected using a food frequency questionnaire that had specific questions about the number of servings of cola and other carbonated beverages and that also made a differentiation between regular, caffeine-free, and diet drinks. The paper finds statistically significant evidence to show that women who consume cola daily have lower bone density. Total phosphorus intake was not significantly higher in daily cola consumers than in nonconsumers; however, the calcium-to-phosphorus ratios were lower. The study also suggests that further research is needed to confirm the findings.

On the other hand, a study funded by Pepsi suggests that low intake of phosphorus leads to lower bone density. The study does not examine the effect of phosphoric acid, which binds with magnesium and calcium in the digestive tract to form salts that are not absorbed, but rather, it studies general phosphorus intake.<sup>[3]</sup>

However, a well-controlled clinical study by Heaney and Rafferty using calcium-balance methods found no impact of carbonated soft drinks containing phosphoric acid on calcium excretion.<sup>[4]</sup> The study compared the impact of water, milk and various soft drinks (two with caffeine and two without; two with phosphoric acid and two with citric acid) on the calcium balance of 20- to 40-year-old women who customarily consumed ~3 or more cups (680 ml) of a carbonated soft drink per day. They found that, relative to water, only milk and the two caffeine-containing soft drinks increased urinary calcium, and that the calcium loss associated with the caffeinated soft drink consumption was about equal to that previously found for caffeine alone. Phosphoric acid without caffeine had no impact on urine calcium, nor did it augment the urinary calcium loss related to caffeine. Because studies have shown that the effect of caffeine is compensated for by reduced calcium losses later in the day<sup>[5]</sup>, Heaney and Rafferty concluded that the net effect of carbonated beverages – including those with caffeine and phosphoric acid -- is negligible and that the skeletal effects of carbonated soft drink consumption are likely due primarily to milk displacement.

Other chemicals such as caffeine (also a significant component of popular common cola drinks) were also suspected as possible contributors to low bone density, due to the known effect of caffeine on calciuria. One other study, comprised of 30 women over the course of a week suggests that phosphoric acid in colas has no such effect, and postulates that caffeine has only a temporary effect which is later reversed. The authors of this study conclude that the skeletal effects of carbonated beverage consumption are likely due primarily to milk displacement.<sup>[6]</sup> (Another possible confounding factor may be an association between high soft drink consumption and sedentary lifestyle.)

## Medical use

Phosphoric acid is used in dentistry and orthodontics as an etching solution, to clean and roughen the surfaces of teeth where dental appliances or fillings will be placed. Phosphoric acid is also an ingredient in over the counter anti-nausea medications which also contain high levels of sugar (glucose and fructose). It should not be used by diabetics without consultation with a doctor. Phosphoric acid is also used as a catalyst in the synthesis of aspirin because it provides a larger number of hydrogen ions with less contamination when compared to hydrochloric acid and sulfuric acid.<sup>[7]</sup>

## Preparation of phosphoric acid

Phosphoric acid can be prepared by two routes - the Thermal Process and the Wet Process.

**Thermal phosphoric acid:** This very pure phosphoric acid is obtained by burning elemental



phosphorus to produce phosphorus pentoxide and dissolving the product in dilute phosphoric acid. This produces a very pure phosphoric acid, since most impurities present in the rock have been removed when extracting Phosphorus from the rock in a furnace. The end result is food grade, thermal phosphoric acid; however, for critical applications additional processing to remove arsenic compounds may be needed.

**Wet phosphoric acid:** Wet Process Phosphoric acid is prepared by adding sulfuric acid to calcium phosphate rock. The simplified reaction is:  $3\text{H}_2\text{SO}_4 + \text{Ca}_3(\text{PO}_4)_2 + 6\text{H}_2\text{O} \leftrightarrow 2\text{H}_3\text{PO}_4 + 3\text{CaSO}_4 \cdot 2\text{H}_2\text{O} + 6\text{H}_2\text{O}$

Wet process acid can be purified by removing fluorine to produce animal grade phosphoric acid or by solvent extraction and arsenic removal to produce food grade phosphoric acid.

## Other applications

Used as the electrolyte in Phosphoric-acid fuel cells. Used as an external standard for phosphorus-31 NMR.

Phosphoric acid is used as a cleaner by construction trades to remove mineral deposits, cementitious smears, and hard water stains. It is also used as an ingredient in some household cleaners aimed at similar cleaning tasks.

Hot phosphoric acid is used in microfabrication to etch silicon nitride ( $\text{Si}_3\text{N}_4$ ). It is highly selective in etching  $\text{Si}_3\text{N}_4$  instead of  $\text{SiO}_2$ , silicon dioxide.

Phosphoric acid is used as a flux by hobbyists (such as model railroaders) as an aid to soldering.

Phosphoric acid is also used in hydroponics pH solutions to lower the pH of nutrient solutions. While other types of acids can be used, phosphorus is a nutrient used by plants, especially during flowering, making phosphoric acid particularly desirable. General Hydroponics pH Down liquid solution contains phosphoric acid in addition to citric acid and ammonium bisulfate with buffers to maintain a stable pH in the nutrient reservoir.

Phosphoric acid is used as a pH adjuster in cosmetics and skin care products.[3]  
(<http://www.cosmeticscop.com/learn/dictionary.asp?TYPE=SEARCH&ID=P>)

Phosphoric acid is used as a chemical oxidizing agent for activated carbon production [8].

## References

1. ^ phosphoric acid. The Columbia Encyclopedia, Sixth Edition. 2001-05 (<http://www.bartleby.com/65/ph/phsphracid.html>)
2. ^ Tucker et al. Am. J Clin. Nut. Oct 2006. Colas, but not other carbonated beverages, are associated with low bone mineral density in older women: The Framingham Osteoporosis Study. ([http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=pubmed&cmd=Retrieve&dopt=AbstractPlus&list\\_uids=17023723&query\\_hl=1&itool=pubme](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=pubmed&cmd=Retrieve&dopt=AbstractPlus&list_uids=17023723&query_hl=1&itool=pubme))
3. ^ Elmståhl S, Gullberg B, Janzon L, et al. Increased incidence of fractures in middle-aged and elderly men with low intakes of phosphorus and zinc. Osteoporos Int 1998;8:333–40.
4. ^ Robert P Heaney and Karen Rafferty, Carbonated beverages and urinary calcium excretion

- (<http://www.ajcn.org/cgi/content/abstract/74/3/343>), American Journal of Clinical Nutrition, Vol. 74, No. 3, 343-347, September 2001
5. ^ Barger-Lux MJ, Heaney RP, Stegman MR.[1] (<http://www.ajcn.org/cgi/reprint/52/4/722?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&author1=Barger-Lux+&andorexactfulltext=and&searchid=1&FIRSTINDEX=0&sortspec=relevance&resourcetype=Effects+of+moderate+caffeine+intake+on+the+calcium+economy+of+premenopausal+women>). American Journal of Clinical Nutrition, Vol. 52:722–725
  6. ^ Robert P Heaney and Karen Rafferty, Carbonated beverages and urinary calcium excretion (<http://www.ajcn.org/cgi/content/abstract/74/3/343>), American Journal of Clinical Nutrition, Vol. 74, No. 3, 343-347, September 2001
  7. ^ Abdullah Rathur
  8. ^ C. Toles, S. Rimmera and J. C. Hower. Production of activated carbons from a washington lignite using phosphoric acid activation. Carbon 1996 [2] ([http://dx.doi.org/10.1016/S0008-6223\(96\)00093-0](http://dx.doi.org/10.1016/S0008-6223(96)00093-0))

## External links

- International Chemical Safety Card 1008 ([http://www.ilo.org/public/english/protection/safework/cis/products/icsc/dtasht/\\_icsc10/icsc1008.h](http://www.ilo.org/public/english/protection/safework/cis/products/icsc/dtasht/_icsc10/icsc1008.h))
- National Pollutant Inventory - Phosphoric acid fact sheet (<http://www.npi.gov.au/database/substance-info/profiles/71.html>)
- NIOSH Pocket Guide to Chemical Hazards (<http://www.cdc.gov/niosh/npg/npgd0506.html>)
- Excel spreadsheet containing phosphoric acid titration curve, distribution diagram and buffer pH calculation ([http://www2.iq.usp.br/docente/gutz/Curtipot\\_.html](http://www2.iq.usp.br/docente/gutz/Curtipot_.html))
- General Hydroponics Liquid pH Down MSDS fact sheet ([http://genhydro.com/genhydro\\_US/msds/pH\\_Down\\_Wet.pdf](http://genhydro.com/genhydro_US/msds/pH_Down_Wet.pdf))

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